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THE APPLICABILITY OF NUCLEAR POWER
IN LESS DEVELOPED AREAS

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The Applicability of Nuclear Power in Less Developed Areas
by

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1- General:

(a) Fortunately the problem of application of nuclear energy cannot be separated into categories as problem for fully developed countries, and under developed countries as far as the technical part of the application is concerned. The problem has the similar conditional requirements which based mostly on the economical situation of the country which may plan to use nuclear power for her industry or for domestic use.

(b) The load forecasting for the countries could be the best criteria in making decision if the nuclear power will be used at a given specific time. This means that the total energy sources of the country, developed or not, will be assessed and their worth of utilization must be evaluated on the basis of the present and possible forecastable future cost of the power of all possible natural resources, if nuclear power is found to be more economical than the others, then it will be the major criteria in policy making decision for energy development efforts.

(c) The international agencies have already made several investigations on the power resources of the world and the under developed countries are trying to assess the raw materials and resources of their countries as accurate as possible in order to make intelligent decisions for the development of their power system. In fact, only on the basis of such studies enough data will be collected for engineers, scientists, and economists for finding the optimum solution to the power development problems.

(d) the studies made by various under developed countries indicated that within the next fifty years there will be justification to use nuclear power¹. It is therefore necessary for the lesser developed countries to be prepared for such an event by training, operating, and planning personnel for nuclear power development. Happily, most countries now have some kind of research reactor which could be used to train technical personnel for their future needs. The International Atomic Energy could co-ordinate their effort by helping these countries.

(e) The problem of development of the nuclear power plant studied for Turkey indicated that a country which possesses very large hydro potential as well as conventional fuels may justify to have nuclear power for industrial and commercial uses if the load growth follows the predicted path and the cost of the nuclear power becomes competitive with the conventional power. The conclusion reached for Turkey will certainly be applied to most of the under developed countries which do not have as much conventional power resources as Turkey. The similar conclusions were reached by most of the under developed countries as seen in the Second United Nations International Conference on the peaceful use of atomic energy held in Geneva, in 1958.

2 - The cost of Nuclear and Conventional Power

(a) The unit capital cost of nuclear power is larger than that of conventional power at the present time. However, the difference is being reduced constantly as the experience accumulates on the design and the operation of the nuclear power plants. The unit cost will continue to be in favour for conventional fueled power plants for smaller sizes. But, the advances made in the field have already made it possible to consider nuclear power plants of 100 MW ranges as economical competing with the others. The cost of electricity in general varies very widely with the location and the size of the power plants.

1.: Peaceful Uses of Atomic Energy

Volume I, United Nations

Geneva (1958)

The table I shows the summary of the power plant costs averaged for USA.

Table I - Power Plant Costs in the USA²

<u>Type</u>	<u>Range</u>	<u>\$/KW</u>	<u>Mills/KWh</u>
Coal-fired plants	400-600 MW	135	2.8
	100-200 MW	150	3.2
	10-50 MW	165	3.5
	Reserved coal pile	7	0.15
	fuel costs \$6-8 per ton		2.4-3.2
Diesel plant	1 MW	160	3.1
	10 MW	140	3.0
	15 MW	135	2.9
	fuel costs 14 ¢/per gallon		9.0
Hydro-electric	200 MW	115	2.5
	100 MW	120	2.6
	50 MW	125	2.7
	10 MW	170	3.6
	Dam and Site	100-200	2.1-4.3

The figures of table I indicates that if all transmission costs are neglected, then the cost of electricity with coal-fired plants varies from 5.4 mills/KWh to 6.4 mills/KWh, with diesel plants from 11.9 mills/KWh to 12.4 and for hydro power plants from 4.7 mills/KWh to 2.9 mills/KWh. In the latter case, the cost of dam and dam-site effects the net result of the power cost very greatly.

(b) The accumulation of the information about the utilization of nuclear power plants also made it possible to reduce the cost of manufacturing of nuclear power plant equipments. On the other hand, the operational experiences will guide the engineers to reach to an optimum design in plant safety requirements as well as in site selection which seems to be an important item in the capital costs of the plants at the present time.

2.: J. Gueron, J. A. Lane, I. R. Maxwell, J. R. Menlee

The Economics of Nuclear Power, Volume I,
UNESCO (1959)

(c) The fuel cost will play a predominant part in the planning of the nuclear power. Here, if the country possesses the required raw material for nuclear fuel production, it may then be possible that by some bilateral agreement with those countries which process and produce nuclear fuel, the required fuel for power production can be obtained at comparative prices. If, on the other hand, the concerned country does not have any raw material then, the problem reduces to the comparison of the cost of nuclear fuel imported and that of other conventional fuel produced or imported for power production. In any event, if the fuel costs substantially lower than those of conventional fuel, then there will be a justification to consider nuclear power plants.

(d) Operations of the characteristics of the power system such as the load factors also effect the cost of power generation very greatly. J.M.Key³ in his paper showed that the cost of electricity for nuclear power plant at load factors more than 40 per cent would be very much less than the cost of electricity for the coal-fired plants. On the other hand, very high percentage load factors can only be obtained in highly industrilized countries. Thus, it is necessary that, the under developed country must at least have some region highly industrilized in order to justify the use of large base load power plants which could be nuclear type. In reference 3 the cost of nuclear power plants and hydro power plants was given which indicates that only for load factors more than 60% nuclear power may be comperable to hydro power, if it has the large head and much less favourable storage areas. For hydro power plants built on large run of rivers or on site with favorable storage areas, the capital cost are always in favour of hydro-plants when comparing with conventional nuclear plants of the present types in use.

3 - The Effect of the Development Plans

(a) The economic and social forces in the under developed countries are effecting the way of lives of the people of these countries so much that, practically every one of the so called under developed countries are making plans for the redevelopment of their country. The plans produced by the Planning Boards of these countries give very high importance to the development of power systems which will be the first requirements for industrilization. The objectives of such plans are to find the optimum relations between the required total national investment and set goals for the increase of net national income per year. It is

3. J.M.Key, The Role of the Nuclear Energy in Relation of Other Methods of Electricity Generation

possible for the planning experts to draw-up the development programs for all the sectors of economy of the country, by using the following facts:

- (i) the rate of increase of population
- (ii) the pre-development per capita income
- (iii) the required or fixed goal for per capita income
- (iv) assessed information on:
 - a. natural resources
 - b. human resources
 - c. industrial and agricultural resources.

From these fixed objectives for industry and other sector of economy, the development plan will be emerged which will also include the requirements for electrical energy in different periods of the development programs. The power authorities must therefore, in turn, make their own power system development by taking all available resources into consideration. The power authorities should consider all possible sources of energy for power development and they should try to estimate the cost of the power generation⁴ with various resources including the nuclear fuels for an optimum decision.

(b) The energy requirements for the planned industries in the development programs will effect very greatly the policy of utilization of energy resources of the country. The policy for the development of the power system may include nuclear power plants if in addition to the conditions defined in paragraphs 2a-d, other technical aspects such as given below exist.:

- (i) Multi utilization of nuclear fuels by using a breeder power stations, the power output would be increased by a hundred percent. The essence of this system is to use plutonium as fuel for power station which simultaneously thorium would be converted into uranium 233. It is expected that the doubling period for this system can be estimated to be in 5 to 6 years⁵ and such cycles may be repeated. Hence, the cost of conventional fuel power generation would be higher than the generation for breeder power plants.
- (ii) The conventional fuels will load the transportation system so much that, if all the estimated power for the country produced by coal-fired power plants in future, it may require a huge investment for the transportation system which, in turn, increases the cost of energy and manufactured goods.

4. Introduction to the Methods of Estimating Nuclear Power Generating Costs, Technical Report's series, No.5
IAEA, VIENNA (1961)

5. H. J. Bhabha, The Need for Atomic Energy in the Under-Developed Countries, Peaceful Uses of Atomic Energy, Vol.I, UN, Genova
(1958)

- (iii) Since most countries including under developed areas have some kind research reactor for research and isotop production purposes where nuclear engineers and scientists will be trained. It is, therefore, possible to use the knowledge and experiences of these trained people. The authorities bound to face the pressure of them for development of nuclear power plants. However weak, this psychological fact should not be underestimated.

4 - Power and Energy for Turkey:

(a) Resources:

Studies made by the Bureau of Electrical Etude Organization(EIEI), and General Directorate of Mining Exploration Organization indicated that, Turkey possesses considerable natural resources for power production. Turkey's known hydro-potential, which can be developed economically, amounts to 25×10^6 kW yielding 90.000×10^6 KWh of electrical energy⁽⁶⁾. Unfortunately, most of these hydro power are located in Eastern Turkey while the industry and large load centers are in western Turkey. Therefore, considerable transmission costs must be contemplated for their utilization. Turkey's coal reserves are divided into two groups:

- (i) High quality black-coal which has a known reservoir of 600×10^6 metric ton⁽⁷⁾, and estimated reservoir of 1332×10^6 metric ton. The requirements of the present and planned heavy industry do not justify to use high quality coal for future power development⁽⁶⁾. Another factor is that, the high quality coal is located around Zonguldak which prohibits its transportation over a long distance.
- (ii) Brown coal:
The known brown-coal reservoirs of Turkey have a capacity of 400×10^6 metric ton. Their use for power production increased since 1955⁽⁸⁾. Unfortunately, they must be used locally where condensation water for power plants seems to be a serious problem.

6. M. N. Parlar, K. Sarioglu, Türkiye ve Atom Enerjisi, Chapter III
T.G.S. ARGE, Ankara (1956)
7. Symposium on Coal
CENTO, Dec. (1961)
8. Türkiye Elektrik Enerjisi İstatistik Bülteni (1959)
EIEI Publication (1960)

(iii) Liquid fuel:

Turkey has a limited petroleum reservoir which cannot be considered for large power production.

(iv) Nuclear fuel:

The explorations made by MTA indicated that, there are, at least, four regions in Turkey which may provide rich raw materials for fuel production. The conclusive results will be obtained after further geological researches in those and other regions in the country.

(b) The past, present and estimated power and energy requirements for Turkey follow an interesting pattern. Table 2 shows the trend in power generation and expected or estimated energy requirements for the years 1940-1975 (7).

Table 2 - Gross Production and Estimated
Production of Electricity for
the years 1940-1975.

UNIT - 10^3 Kwh.

Year	Thermal	Hydro	Total
1940	383.004	13.894	396.898
1945	504.046	23.762	527.808
1950	759.524	30.100	789.624
1955	1.490.668	89.150	1.579.818
1960	1.813.661	1.001.410	2.811.071
1961 M	1.773.500	1.276.500	3.050.000
1965 E	-	-	6.370.000
1970 E	-	-	9.150.000
1975 E	-	-	13.000.000

M= provisional figures, E= estimated figures.

It should be noted that, the estimated energy requirements in table 2 corresponds to a per capita energy of 200 kwh-P/Y, 250 Kwh-P/Y, and 310 Kwh-P/Y for the years 1965, 1970, and 1975 respectively which are less than the figures exist for Bulgaria, Yugoslavia and other European countries reached in 1960.

Table 3 shows the past, present, and estimated required installed capacity in Kws.

Table 3 - Installed and Estimated Capacities
for 1940-1975.

UNITS-in Kw.

Years	Thermal	%	Hydro	%	Total
1940	209.946	96.8	7.016	3.2	216.965
1945	235.962	95.9	9.976	4.1	245.938
1950	389.896	95.6	17.885	4.4	407.781
1955	573.515	93.8	38.118	6.2	611.633
1960	860.528	67.6	411.904	32.4	1,272.432
1961 M	881.200	65.6	462.023	34.4	1,343.223
1965 E	-	-	-	-	1,973.000
1970 E	-	-	-	-	2,740.000
1975 E	-	-	-	-	3,250.000

M= provisional figures, E= estimated figures.

For an under developed country it is not possible to calculate the future capacity and energy requirements by the same methods used for the developed countries. The best, engineers in under developed countries, can do, is to study historically the industrial development of many countries and select the one which shows similarity for their country as a guide. By comparative method one can easily see that the estimated figures in the last two tables are very reasonable. On the basis of Table 3, it is necessary that during the next three-five years interval-Turkey should add 650 MW, 760 MW, and 610 MW capacities to her power system.

(c) Turkey will try to use her enormous hydro-potentials more and more in order to keep pace with the power demand. The details of the new five year development plans submitted to National Assembly is not known yet. But, it is expected that there will be large industrial developments in the Eastern Turkey on the Euphrates and Tigres river basins which will use rich hydro-potentials. However, Istanbul region still will continue to expand her industrial complex, and power demand will increase in accordance with doubling the peak demand on every decade.

5- Conclusion: The trend in the cost of nuclear power will make it more attractive within the next few decades. The operational problems of nuclear power plants are not too prohibitive for lesser developed countries to learn. The training can be done for either if one has to start from beginning.

The power requirements in Turkey and especially in Istanbul region may open a possibility for nuclear power development by 1980, if the load follows the estimated pattern which shows similarity to some European country now are considering nuclear power plants.

